INTEGRATED THERMOELECTRIC MODULE

Technical field

The present invention generally refers to the field of solid-state thermoelectric devices using the Peltier effect to cool and/or heat civil and/or industrial environments.

Prior art

The thermoelectric devices of the abovementioned type have been known in the art for quite some time and generally comprise a thermoelectric module or thermopile consisting of a set of thermoelectric elements which, in their turn, are formed by P type and N type conductor and/or semiconductor elements electrically connected in series and thermally connected in parallel, wherein the thermoelectric elements are usually electrically connected in series and thermally connected in parallel and are assembled on supports made of electrically insulating, but thermally conductive, material and generally made of stiff ceramic material. These thermoelectric modules must then be connected to heat exchangers in order to form heat pumps for household and industrial appliances.

The thermoelectric modules known in the art generally present some drawbacks related to their thermal efficiency and fragility. As to the first of these drawbacks, in particular, the thermoelectric modules known in the art do not allow to achieve a uniform temperature distribution on the heat exchangers to which they are connected, because they cannot be adapted to the variable characteristics of the

heat exchangers depending on the type of application they are intended for. As to the second drawback, it is known that, because of the fragility of the support, during the assembly steps with the heat exchangers ruptures frequently occur due to the high contact pressures required for good functioning and/or during operation due to the different thermal expansions of the two faces of the module, caused by the different temperatures of the heat exchangers they are connected to.

Disclosure of the invention

The present invention pursues the object to overcome said drawbacks of the thermoelectric modules known in the art by providing a newly designed thermoelectric module that is to be assembled and integrated with heat exchangers in order to form a thermoelectric heat pump.

According to the present invention, this object is achieved by a integrated thermoelectric module formed of a set of thermoelectric elements, each of which is made of P type and N type conductor and/or semiconductor elements electrically connected in series and thermally connected in parallel, wherein said thermoelectric elements are electrically connected in series and/or in parallel and thermally connected in parallel and are assembled on flexible supports made of a polymeric material capable of electrically insulating the circuit, but having a high thermal conductivity performance. Said supports, one being on the hot side and the other on the cold side of the thermoelectric module, are connected to their respective heat

exchangers by means of connecting materials having low thermal impedance, for instance of phase conversion type or graphite-base type, allowing optimum connection even at low adhesion pressures. Said integrated module is characterized in that the thermoelectric elements are distributed in its interior so as to geometrically harmonize heat transferred from the integrated thermoelectric module with heat exchanged by the heat exchangers, thus making the temperature distribution on said heat exchangers as uniform as possible, in order to maximize the efficiency of the integrated thermoelectric module by reducing the thermal head between its two faces.

Brief description of the drawings

The present invention will now be described as a non-limiting example with reference to the figures of the accompanying drawings, in which:

figure 1 is a sectional view of the integrated thermoelectric module according to the invention, associated with heat exchangers of planar form in order to form a thermoelectric heat pump;

figure 2 is a sectional view of the integrated thermoelectric module according to the invention, associated with heat exchangers of concave and/or convex form in order to form a thermoelectric heat pump;

figure 3 is a sectional view of the integrated thermoelectric module according to the invention, associated with heat exchangers

of cylindrical form with a polygonal cross section in order to form a thermoelectric heat pump; and

figure 4 is a sectional view of the integrated thermoelectric module according to the invention, associated with heat exchangers of cylindrical form with circular cross section in order to form a thermoelectric heat pump.

Best mode of carrying out the invention

Referring to figure 1 of the drawings, the integrated thermoelectric module 10 is formed of a set of thermoelectric elements, as described above, assembled on flexible supports 11 having the form of a thin membrane or film of polymeric material. The thermoelectric elements are uniformly or non-uniformly distributed on the flexible support 11 depending on the particular use the thermoelectric module 10 is intended for.

The peripheral shape of the integrated thermoelectric module may be different and may be rectangular, for instance even square, or curvilinear, for instance circular.

The polymeric material of the flexible support 11 is preferably made of a polyimide, commercially available under the trade name Kapton®.

The integrated thermoelectric module 10, thus formed, is associated with heat exchangers 12 and is caused to adhere to the base surfaces of the latter, preferably by means of a thermo conductive material 13 of phase conversion type. Instead of the thermo conductive material of phase conversion type, a graphite

material may be used as connecting material, laid on one side only or on both sides of the integrated thermoelectric module 10.

The base surfaces of the heat exchangers may be planar, as shown in figure 1, or concave and/or convex, as shown in figure 2, or cylindrical with a polygonal cross section, as shown in figure 3, or cylindrical with circular cross section, as shown in figure 4. Heat exchangers 12 may be touched by gaseous or liquid fluids as well as by fluids undergoing phase conversion. In addition, the surfaces being touched may be provided with fins. The heat exchangers 12 may be made of metal or non-metal material. For instance, as non-metal material, a graphite material may be used.

The connecting materials used to connect the integrated thermoelectric module 10 to the heat exchangers 12 may be either distributed in a substantially uniform way on the flexible support 11 or they may be localized on the flexible support 11 in correspondence with the thermoelectric elements.

The technical advantages achieved with a thermoelectric device according to the invention are as follows.

With a proper distribution of the thermoelectric elements inside the integrated thermoelectric module 10, it is possible to harmonize the configuration of said module with that of the heat exchangers 12 in order to improve the correspondence between heat transferred from the module and heat exchanged by the heat exchangers 12 and to achieve a temperature distribution as uniform as possible, thus

improving efficiency of the integrated thermoelectric module 10 with reduction of the thermal head between its two faces.

Industrial applicability

The use of a connecting material between integrated thermoelectric module 10 and heat exchangers 12, as described, permits to obtain a stable connection even in the absence of an excessive contact pressure in order to achieve close contact between integrated thermoelectric module and heat exchangers. In addition, said connecting materials have high thermal conductivity and are capable of absorbing, in the best possible manner and without damages to the module itself, possible thickness irregularities of the module due to different height of the thermoelectric elements and differential effects in terms of thermal expansion of the heat exchangers, when, during operation, they find themselves at mutually different temperatures. Finally, if heat exchangers are used having non-planar adhesion surfaces, said connecting materials could be used to offset non-conformity of the planar base of the thermoelectric elements with the curvature of the exchanger base, by filling up the interstices that are present between flexible support 11 and surface of heat exchangers 12.